Arrowheads from the Santa Cruz Islands (Temotu, Solomon Islands): design, raw material, and how they are linked

Jean-Marc Pétillon, Aurore Lemoine, Katharina Müller, Ina Reiche

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1997 – 1st meeting – London (United Kingdom)

Riddler I. (ed.) 2003: Materials of Manufacture: The Choice of Materials in the Working of Bone and Antler in Northern and Central Europe During the First Millennium AD. British Archaeological Reports, International Series 1193. Oxford.

1999 – 2nd meeting – Budapest (Hungary)

Choyke A.M. / Bartosiewicz L. (eds.) 2001: Crafting Bone: Skeletal Technologies through Time and Space – Proceedings of the 2nd meeting of the (ICAZ) Worked Bone Research Group Budapest, 31 August – 5 September 1999. British Archaeological Reports, International Series 937. Oxford

2003 – 4th meeting – Tallinn (Estonia)

Luik H. / Choyke A.M. / Batey C. / Lougas L. (eds.) 2005: From Hooves to Horns, from Mollusc to Mammoth – Manufacture and Use of Bone Artefacts from Prehistoric Times to the Present –Proceedings of the 4th Meeting of the ICAZ Worked Bone Research Group at Tallinn, 26th–31st of August 2003. Muinasaja teadus 15. Tallinn

2007 – 6th meeting – Paris (France)

Legrand-Pineau A. / Sidéra I. / Buc N. / David E. / Scheinsohn V. (eds.) 2010: Ancient and Modern Bone Artefacts from America to Russia. Cultural, technological and functional signature. British Archaeological Reports, International Series 2136. Oxford

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Contents

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Design, Raw Material, and how they are linked

Jean-Marc Pétillon / Aurore Lemoine / Katharina Müller / Ina Reiche

Abstract

Several written sources from the 19th and early 20th century indicate that, on the Melanesian archipelago of Santa Cruz, the heads of the war arrows were made of human bone. The aim of this study was to consider this behavior from the perspective of bone tool technology: confirm the choice of human bone as raw material and understand how it influenced the conception of the projectile and its point. A sample of 57 arrows collected on the Santa Cruz islands in the late 19th - early 20th century was thus studied in order to (1) establish the range of typological and technological variation in point design; (2) determine the nature of the raw materials used; (3) discuss the relationship between the two. The typological study shows that the arrowheads can be divided into two main categories, 'large points' (10% of the sample) and 'small points' (88% of the sample), and that the latter are designed as imitations of the former. Material analyses performed on four points show that the large points are made of bone, the species of which could not be determined; however the small points, which make up the large majority of the sample, are not made of bone but probably of keratinous material. This apparent discordance between the written record and the analysis of the artifacts may be due the heterogeneous and patchy nature of our sources, or to the existence, in the culture of the Santa Cruz islanders, of a gap between the ideology and the actual technical practice.

Keywords: Santa Cruz Islands; arrowhead; imitation; human bone; infrared spectroscopy

The technical use of osseous materials is conditioned by their morphometric and physical-chemical characteristics – as is the case for all raw materials. Dimensions, shape, composition and structure determine the properties of the bone (e.g., stiffness and toughness) and hence its workability, adaptation to use and even esthetic aspects (gloss, fineness of grain, translucence, etc.). However, because they originate from the animal world, osseous materials are also intimately associated with the animal they were taken from. It has long been suggested that, because of this particular feature, osseous raw materials may have been embodied with specific qualities related to the species they belong to (McGhee 1977). As Olsen put it, "the animal's attributes and its role in a culture's belief system often influence the selection of that species' elements for artifacts" (Olsen 2007, 180). This influence is documented in the ethnographic record – e.g., the *osso di cavallo* described by Choyke (oral presentation at the Salzburg WBRG conference) – and it has also been considered in interpretations of prehistoric technologies, especially when discussing the use of bones from domestic species vs. wild species in Neolithic societies (Le Dosseur 2008; 2010; Sénépart 1993; Sidéra 2000).

This question is most perceptible in the case of human bones used for the manufacture of objects. Obviously, the choice of a human bone as a block of raw material, meant to be turned into an artifact, is never a mundane technical act. It is necessarily intertwined with cultural connotations, and ultimately refers to that culture's conception of humankind (e.g., the New Zealand flutes made of tibias taken from the ancestors' bodies in order to "pass down the spirit through generations": O. Mapp, oral presentation at the Salzburg WBRG conference).

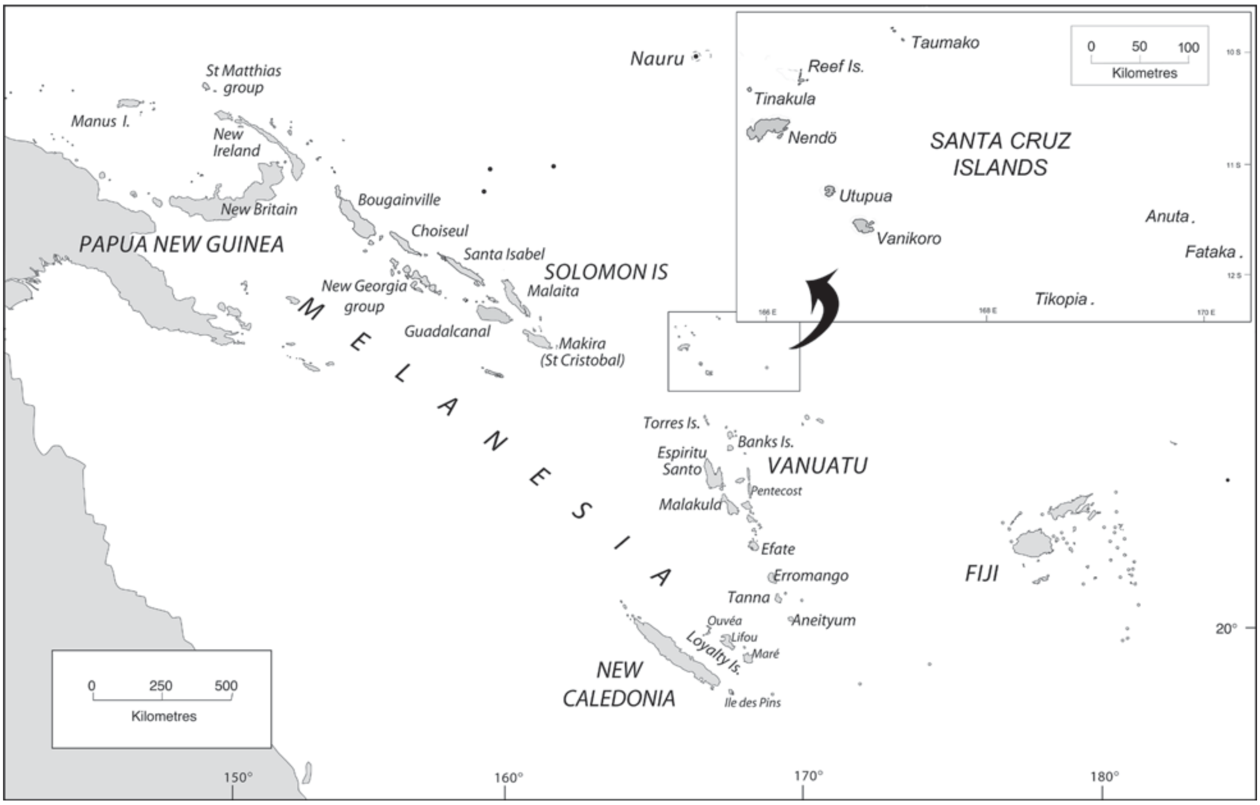

Fig. 1: Map of Melanesia with detail of the Santa Cruz Islands. Modified after Ross / Naess 2007 and McCoy / Cleghorn 1988.

Studying how and why human bones are used as raw material in certain cultures can thus help to illuminate these cultures' system of beliefs and values.

However, the relationship between the ideology and the actual technical practice is not at all simple, and the patchy nature of our documentation makes it even more difficult to grasp. In this article we present preliminary results drawn from one such case: Melanesian arrowpoints allegedly made of human bone.

Context

The objects studied were collected on the Santa Cruz Islands in the late 19th - early 20th century. This group of islands is situated north of the archipelago of Vanuatu, and belongs to the Temotu Province, the easternmost province of the Solomon Islands. The largest island in the group (a little over 500km²) is Nendö, also known as Santa Cruz Island proper, and the other main land masses are Vanikoro and Utupua (Fig. 1). Several Lapita sites excavated in the 1970s show that Nendö, at least, has been populated since ca. 1000 BC (McCoy / Cleghorn 1988). Spanish navigators were the first Europeans to make contact with the inhabitants in the late 16th century; they were followed by the British and the French in the late 18th - early 19th century. Visits of Europeans to Santa Cruz became more frequent after the mid-19th century ('labor' ships, British military and Anglican missionaries: O'Ferrall 1908), and in 1893 the United Kingdom declared a protectorate over the islands.

Fig. 2: Headmen in a village on Nendö, one holding his bow and arrow. After O'Ferrall 1908 and Coombe 1911.

The material and social culture of the Santa Cruz islanders at that period is documented by accounts of navigators from the late 18th - early 19th century (e.g., Labillardière 1800; Dillon 1830; Dumont d'Urville 1833) and literature from missionaries and anthropologists in the late 19th - early 20th century (e.g., Codrington 1891; Graebner 1909; O'Ferrall 1908; Speiser 1916; for more recent ethnography see Davenport 2005; Koch 1971). A comprehensive presentation is of course beyond the scope of this article, and only the information necessary to briefly contextualize the use of the arrowpoints will be given here.

The Santa Cruz islanders (Fig. 2) are a Melanesian population which speak Oceanic Austronesian languages (Næss / Boerger 2008). In the 19th and early 20th century, subsistence was based on horticulture – mostly coconuts, taro and yam – and on the exploitation of seafood (fish, sharks, turtles, mollusks and crabs); pigs were bred, but eaten only on festive occasions. Fishing technology was highly developed, with very diversified techniques and equipment (dams, nets, snares, fishing rods, fishing kites, fishing arrows, etc.: Graebner 1909, 103). Armed conflicts were apparently frequent before the British 'pacification', and the chief war weapons were bow and arrow (mentions of the use of blowpipes and bludgeons are dubious and/or anecdotic at best: Graebner 1909, 132).

As is the rule in Oceania (Patole-Edoumba 1999), the Santa Cruz bows are simple, straight bows (Fig. 3: 1). They have a semicircular cross section and lengths of ca. 180-200cm. Three types of arrows are documented: multipronged, barbed fishing arrows (Fig. 3: 2); blunt fowling arrows (Fig. 3: 3); and pointed war arrows (Fig. 3: 4).

This study focuses on the last category, which is also the most common in museum collections of Santa Cruz arrows. Indeed, while the heads of fishing arrows and fowling arrows are made of wood, the points of the war arrows are usually made of hard animal material, and this material has repeatedly been described as human bone.

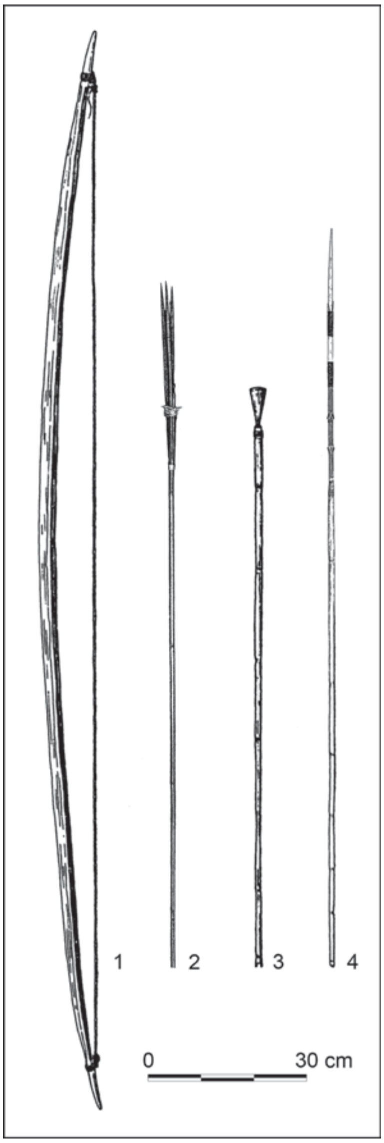

Fig. 3: Santa Cruz bow and a set of arrows. 1: bow; 2: multipronged, barbed fishing arrow; 3: blunt fowling arrow; 4: pointed war arrow. Modified after Graebner 1909, fig. 38, and Koch 1971, fig. 12, 22, 23, 137. Length of fishing arrow is estimated.

Archaeological and ethnohistorical data concerning the raw material of the arrowpoints

The Mateone Dance Circle site (SE-SZ-26-1) on Nendö yielded bone projectile points similar to those of ethnographic war arrows. These points were found in layers dating back to 625 ± 140 BP (1150-1525 cal AD: McCoy / Cleghorn 1988). The species used as a source of raw material remains unknown. However, this find undeniably gives a certain time depth to the practice of making bone arrowpoints on Nendö.

Observations made in 1793 on Nendö indicate that the points of some war arrows were made of bone, but that other hard animal materials were used as well: the arrows "had, by means of a reddish mastic, fixed to their extremity a small piece of well sharpened bone, or tortoise-shell, a centimeter long. Other arrows had points of the same substance, from two to three decimeters long. Several too were armed with the bone which is found at the origin of the tail in the species of ray called *raia pastinaca*" (= a stingray's barb; Labillardière 1800, 270-271).

However, later sources report only bone points, and mention the use of human bone for their manufacture. On Vanikoro in 1828, Dillon (1830, vol. 2, 215) witnessed two islanders "each armed with a bow and about twenty arrows, the point of which was made from fragments of human bones[1]". At the same period, on the same island, Dumont d'Urville (1833, 217) wrote that the islanders "acknowledged that they exposed in sea water the bodies of their enemies killed in fight, and let them lay there long enough for the flesh to completely separate from the bones. The skulls were kept as trophies and the slight bones from the extremities were used to form

museum / collection	city	museum number	number of arrows
Musée d'Aquitaine	Bordeaux, France	Mesuret 13159	4
Musée d'Aquitaine	Bordeaux, France	Mesuret 13160	30
Musée d'Aquitaine	Bordeaux, France	Mesuret 13170	2
Museum d'histoire naturelle	Toulouse, France	MHNT-ETH-AC 16	19
Museum d'histoire naturelle	Toulouse, France	MHNT-ETH-AC PO 6	1
private collection	Toulouse, France	none	1
total			57

Tab. 1: Composition of the sample of Santa Cruz arrows.

arrowheads[2]". Later, Lesson (1876, 266) further reported: "It is from the bones of their enemies that the Vanikoro islanders make their arrowheads, and to get these bones, they first let the bodies macerate in the sea[3]".

Describing the burial practices of the islanders on Nendö, Codrington (1891, 263-264) wrote: "At Santa Cruz the corpse is buried in a very deep grave in the house, wrapped in many mats. (…) Inland they dig up the bones again to make arrowheads, and take the skull to keep it in a chest in the house". O'Ferrall (1908) also mentioned this practice on Nendö: "The dead are buried within the hut close to the fireplace. After a time the body is exhumed, some bones are used for making arrowheads, the skull is placed in a basket and kept." Coombe (1911, 190) repeated the same information: "The Cruzians bury their dead at home close to the central oven! (…) In due time the remains are disinterred, what bones are desired are taken for making arrow-heads, and the skull is preserved in a basket." Koch (1971, 172) also reported: "Most of the war arrows are equipped with bone points (allegedly carved from the exhumed arm- or leg-bones of deceased relatives, both men and women)[4]." On the basis of these sources, modern exhibition catalogs

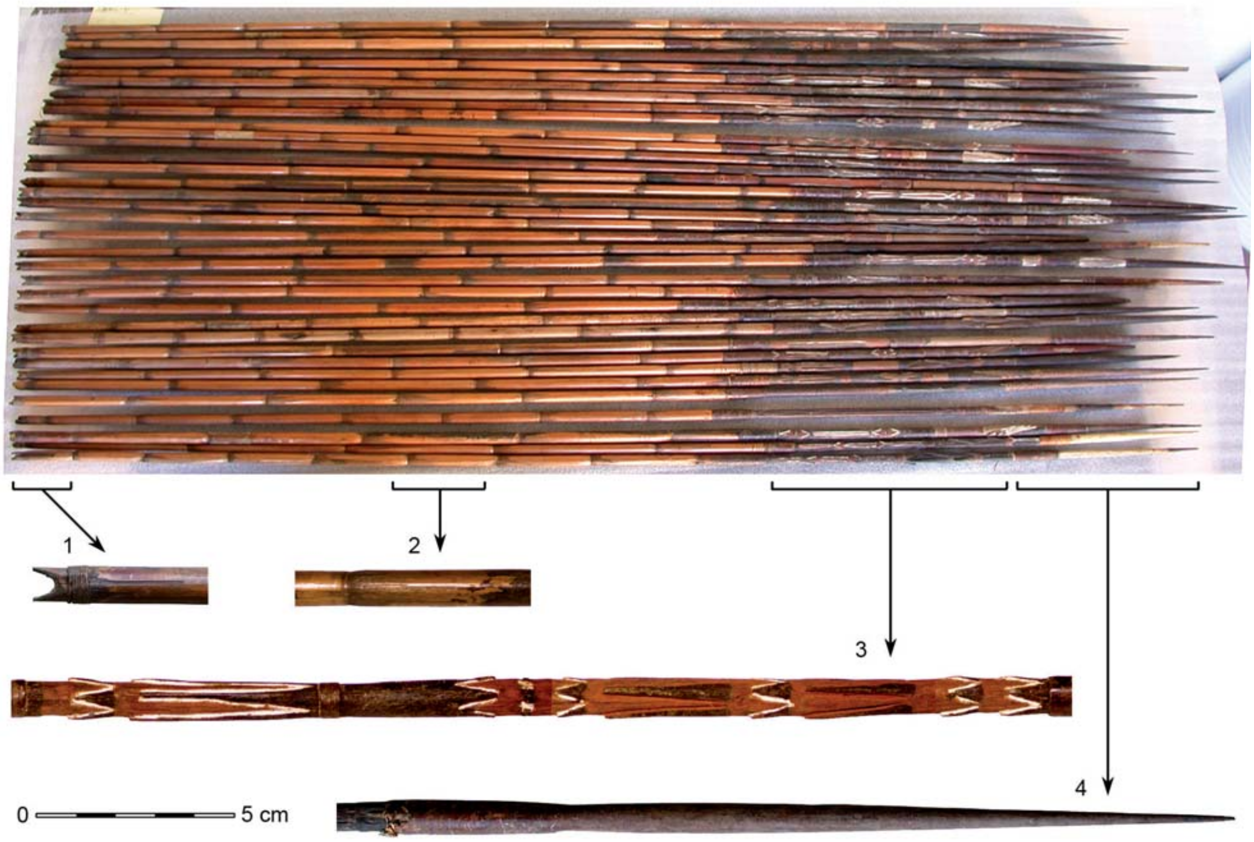

Fig. 4: General view of the 36 Santa Cruz arrows in the Musée d'Aquitaine collections, and details. 1: notch for the bowstring; 2: shaft; 3: foreshaft; 4: head. Pictures: J.-M. P.

still describe the Santa Cruz arrowheads as made of human bone (e.g., Collective 2002).

Before this behavior can be interpreted in any way, it was first necessary to consider it from a perspective of bone tool technology: confirm the choice of human bone as raw material and understand how it influenced the conception of the projectile and its point. Samples of Santa Cruz arrowpoints were thus studied in order to (1) establish the range of typological and technological variation in point design; (2) confirm the nature of the raw materials used; (3) discuss the relationship between the two.

Material

The main assemblage analyzed in this study is a collection of 36 arrows kept at the Musée d'Aquitaine (Bordeaux, France). The majority of these arrows belongs to the Daleau collection and were already partly described by Passemard (1917). The museum's catalog indicates that these arrows are from the New Hebrides (i.e., Vanuatu). However, their typology and decoration are characteristic of the Santa Cruz islands (Graebner 1909; Koch 1971; Speiser 1909); arrows of this type are, furthermore, absent from Speiser's extensive description of the Vanuatu material culture (1991). Therefore, there can be no doubt about their origin, and the mention of the New Hebrides must be considered erroneous. The assemblage from the Musée d'Aquitaine was complemented by the collection of 20 arrows from the Santa Cruz islands kept at the Toulouse Museum of Natural History, and by one arrow from a private collection, for a total of 57 arrows studied (Tab. 1).

All arrows were made following the same general pattern (Fig. 4). The length of the complete specimens varies between 115 and 128.5cm. The bamboo shaft is 71-83.5cm long, with a maximum diameter generally between 1 and 1.2cm; at the proximal end is a notch for the bowstring. Fletching is absent, which is a frequent feature of Oceanian arrows (fletched arrows are encountered only in the Solomon Islands, Vanuatu and Tonga after Patole-Edoumba 1999). The wooden foreshaft is generally 24.5-31.5cm long, with a maximum diameter between 0.8 and 1.3cm; it is almost always finely decorated. Finally, the distal part of the projectile, or 'head', is 16.7-22.4cm long and has a maximum diameter of 0.9-1.2cm.

Although the main focus of this study is on the arrowheads, a point must be made regarding the decoration of the foreshaft (Fig. 5). This decoration is usually based on a register of red, white and black linear patterns, repeated and alternated in various ways along the length of the foreshaft. But despite these variations, all 57 foreshafts in our sample can be attributed to one of the five following types:

Fig. 5: The three most common types of foreshafts on the Santa Cruz arrows. 1: type C; 2: type D; 3: type E. See description in text. Pictures: J.-M. P.

- A: undecorated foreshaft (n = 1, or 2%; not illustrated).
- B: this type has an undecorated segment just below the head; below this segment is a succession of red, white and black linear patterns (n = 3, or 5%; not illustrated).
- C: this type is decorated with red, white and black linear patterns along all its length (n = 7, or 12%; Fig. 5: 1).
- D: this type is characterized by the presence of a black 'barbed' pattern, always placed slightly below the head, never repeated twice and

Fig. 6: The three types of points on the Santa Cruz arrows; photograph and radiograph. 1: composite point; 2: large point; 3: small point (on 3, photograph and radiograph are from two different arrows). Pictures: J.-M. P.; radiographs: M. Bessou, UMR 5199 PACEA.

surrounded by red, white and black linear patterns (n = 19, or 33%; Fig. 5: 2).

E: this type is characterized by the presence of a black and white ‘chevron’ pattern, always placed immediately below the head, never repeated twice, followed by two red- and black-colored bands and then red, white and black linear patterns (n = 27, or 47%; Fig. 5: 3).

The same foreshaft types can be identified on the Santa Cruz arrows shown by Graebner (1909, 137), Speiser (1909, 310) and Koch (1971, plate 25). Speiser already remarked on the recurrence of some of these types, especially the incompatibility between the barbed and the chevron patterns. The correlation between these types and the typology of the arrowheads will be discussed below.

Results of the typological study

The arrowheads can be divided into three distinct types. The first type is the *composite point* (Fig. 6: 1): the head is actually made of two segments, the bone point itself and a bone foreshaft. The bone point has a bifid forked base and the bone foreshaft has a symmetrical bifid forked distal end; these two extremities are interlocked and the joint is covered by a lashing. This composite bone head is then fixed to the wooden foreshaft through a similar fork-shaped hafting. This type is the rarest in our sample (n = 1, or 2%). The single specimen is hafted to a type C wooden foreshaft, and has overall dimensions of 25.3 x 0.9 x 0.7cm. Similar composite points are mentioned among the Santa Cruz arrows kept at the Rautenstrauch-Joest Museum in Cologne and at the Museum für Völkerkunde, today Ethnological Museum, in Berlin, published respectively by Graebner (1909) and Speiser (1909).

The second type is the *large point* (Fig. 6: 2). Here, a single bone point is directly hafted to the wooden foreshaft, without an intermediary bone foreshaft, and again through a system of interlocked forks. There are six specimens of this type in our sample (10%), all hafted to type D wooden foreshafts. Most of these points are broken at the distal end, but the estimated length of the complete specimens is ca. 18-22.5cm, with a maximum width of 0.7-0.8cm and a maximum thickness between 0.45 and 0.8cm.

The third type is the *small point* (Fig. 6: 3). Like the ones from the previous type, these points have a forked base and are directly hafted to the wooden foreshaft, but their dimensions are much smaller: ca. 3-6cm in length and 0.3-0.5cm in width and thickness. As a consequence, in this case, the wooden foreshaft is much longer, and the point forms only the extreme tip of the arrow. This type is by far the most common in our sample (n = 50, or 88%). These points are hafted to all types of wooden foreshafts, the most frequent being type D foreshafts (n = 13, or 26% of the small points) and type E (n = 27, or 54% of the small points).

These three categories are truly distinct types: there are no arrowheads with intermediary dimen-

type of arrowhead	type of foreshaft decoration					total
	A	B	C	D	E	
composite points	0	0	**1**	0	0	1
large points	0	0	0	**6**	0	6
small points	1	3	6	13	**27**	50
total	1	3	7	19	27	57

Tab. 2: Type of point and type of foreshaft decoration on the Santa Cruz arrows. The most frequent type of foreshaft decoration for each type of arrowhead is in bold numerals. See description of foreshaft decorations in text.

sions. Furthermore, there are reasons to think that these types were also explicitly distinguished by the arrow makers, since they are reflected in the decoration of the foreshaft. Indeed, large points are exclusively hafted to type D foreshafts, while the small points are hafted to all types of foreshafts and most frequently to type E, which is never encountered with large points (Tab. 2). Thus, despite the difference in sample size between the large points and the small ones, there is clearly a different distribution of foreshaft decoration according to the type of point. Speiser (1909) made the same remark about the Santa Cruz arrows in the Berlin Ethnological Museum.

Fig. 7: Details of the design of the two most common types of arrowheads. 1: large point with mesial part covered with mastic; detail view of the base, showing the protruding tines. 2: large point with mesial part left bare; detail view of the base, showing the protruding tines. 3: small point; detail view of the base showing the hidden hafting (visible here only because mastic is damaged); detail view of the fake hafting on the foreshaft. Pictures: J.-M. P.

Typological interpretation: the model and the imitation

The reason behind this typological variability is not self-evident: why did the Santa Cruz islanders manufacture different types of points for their war arrows and correlate them to some extent with the decoration of the foreshaft? A closer look at the two most common types – large points and small points – suggests several interpretive clues.

On the base of the large points, the lashing at the joint with the foreshaft is clearly visible, bulging and covered with reddish mastic. The point has a forked base and the proximal extremities of the tines always protrude from the lashing (Fig. 7: 1-2). Two of the 6 large points in our sample are totally covered with the reddish mastic, and the only exposed parts are the extremities of the tines protruding from the lashing (Fig. 7: 1); but on the 4 remaining specimens, the mesial part of the point is left bare, making the bone surface visible (Fig. 7: 2).

Conversely, on the base of the small points, the lashing is streamlined, entirely covered with reddish mastic, and the tines of the forked base do not protrude (Fig. 7: 3). As a result, the joint between the point and the foreshaft is hidden: it is invisible unless damaged. Below the point, the distal part of the wooden foreshaft (which is at the same level as the mesial part of the large points) is always covered with reddish mastic, so that its wooden surface is not visible. And below this part of the foreshaft, a ring is carved, in the same place and of the same shape as the lashing of the large points. This feature can obviously be interpreted as a fake lashing (Fig. 7: 3). Furthermore, immediately below this fake lashing, 54% of the arrows with small points show the chevron pattern typical of type E foreshafts (Fig. 7: 3). As noted by Speiser (1909), this pattern might be considered reminiscent of the shape of the forked base on the large points; it might thus be interpreted as a series of fake tines.

These manufacturing peculiarities show that the arrowheads with small points are designed as imitations of the arrowheads with large points. On all 50 arrows equipped with this type of point, the systematic covering of the distal part of the foreshaft with mastic hides the fact that most of the arrowhead is actually made of wood; the hafting of the point is made to be as discreet as possible, and a fake hafting (with a fake lashing, and maybe, in the majority of specimens, a fake forked base) is carved ca. 15cm below, where the true hafting would be in the case of a large point. This phenomenon is akin to 'imitation type 1' as defined by Choyke (2008).

Raw material analysis

To further investigate the significance of this particular design, material analyses were performed on several arrowpoints from the Musée d'Aquitaine at LC2RMF (Laboratory of the Center for Research and Restoration of Museums of France), Paris. This

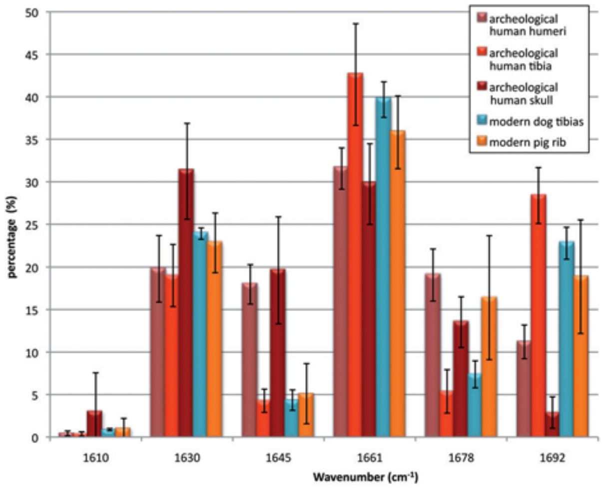

Fig. 8: Amide I histograms of the reference samples.

investigation by infrared spectroscopy in transmission mode (FTIR) aimed at identifying the nature of the raw material used (Lemoine 2010). The idea of this pilot study was to differentiate between various species based on differences in the supra-molecular collagen structure. Infrared spectroscopy combined with spectra decomposition is an appropriate method to analyze the secondary structure of collagen. Previous FTIR analyses on several modern bone samples (4 bovine, 2 sheep, 1 horse and 3 marine mammals) indicated specific differences in respective structural parameters among the species (unpublished data).

The FTIR analyses were carried out by means of a Perkin Elmer Spectrum 2000 spectrometer using a diamond cell. Six measurements were performed on each sample, collecting IR radiation in the spectral range of 4000-250cm^{-1}. For each spectrum 20 scans were made at 2cm^{-1} spectral resolution. The evaluation of FTIR spectra was performed using the PeakFit software. The collagen band in the range of 1600-1720cm^{-1}, called amide I, is representative of the collagen secondary structure. A curve fitting procedure (fourth-derivative analysis) was carried out to determine the proportion of the individual band components (aromatic rings at 1610cm^{-1}, β-sheets at 1630cm^{-1}, random coils at 1645cm^{-1}, α-helix at 1661cm^{-1} and β-sheets at 1678cm^{-1}; details in Chadefaux et al. 2009; Lemoine 2010). The mean contribution of the different vibration modes of the amide I band was then calculated for each sample and expressed as relative area (percentage and standard deviation) on a histogram.

For this investigation the single composite point and two large points were sampled by scraping the surface of the mesial part with a scalpel blade in order to remove a small amount of bone material. Four samples were taken: 2 from the composite point (13170-2 from the bone foreshaft and 13170-1 from the bone point) and one from each of the large points (13159-1 and 13159-2). A fifth sample (13160-1) was taken from one of the small points by cutting off a part of a tine from the forked base. As references samples served: four archaeological human bones (1 skull, 1 tibia and 2 humeri from the Neolithic levels of the Fontbrégoua rock shelter, Var, France), two modern dog tibias and one modern pig rib (these two species being among the rare large mammals locally available to the Santa Cruz islanders in the late 19th and early 20th century). Unfortunately, modern human bone samples were not available for this study. However, according to a former study on modern and archaeological bovine bone (Chadefaux et al. 2009), the general proportions of the individual components of collagen secondary structure were conserved even if slight modifications caused by diagenesis were observed (naturally as a function of the burial conditions). This allows us to use well-preserved archaeological bone material as references for species determination in a first approach.

All archaeological samples were first observed under optical microscope in order to identify the general characteristics of the material. Because of the unusual aspect of sample 13160-1 (see below), a further observation was performed on this sample with a scanning electron microscope coupled with an energy-dispersive X-ray detector (SEM-EDS) in order to analyze the morphology and chemical composition of its surface.

The results obtained on the reference samples indicate differences between the collagen secondary structure of various species, but also show relatively great structural variances within a single species (particularly for the human bones: Fig. 8). The latter could be due to structural characteristics of anatomical elements in a single species. Even if previous analysis revealed only a slight influence of diagenesis on the respective structural parameters, possible diagenetic changes during burial time must be taken into account for the Neolithic bone samples anyway. Further analyses on a much greater quantity and variety of bone samples are required to clarify this issue. Moreover, chemometric data evaluation should be involved.

The results for the Santa Cruz samples were compared to those obtained on the reference samples (Fig. 9). The spectra and histograms of the four Santa Cruz samples are very similar, showing that the two large points and the two segments of the composite point were obviously made from the same type of bone material. However, there are

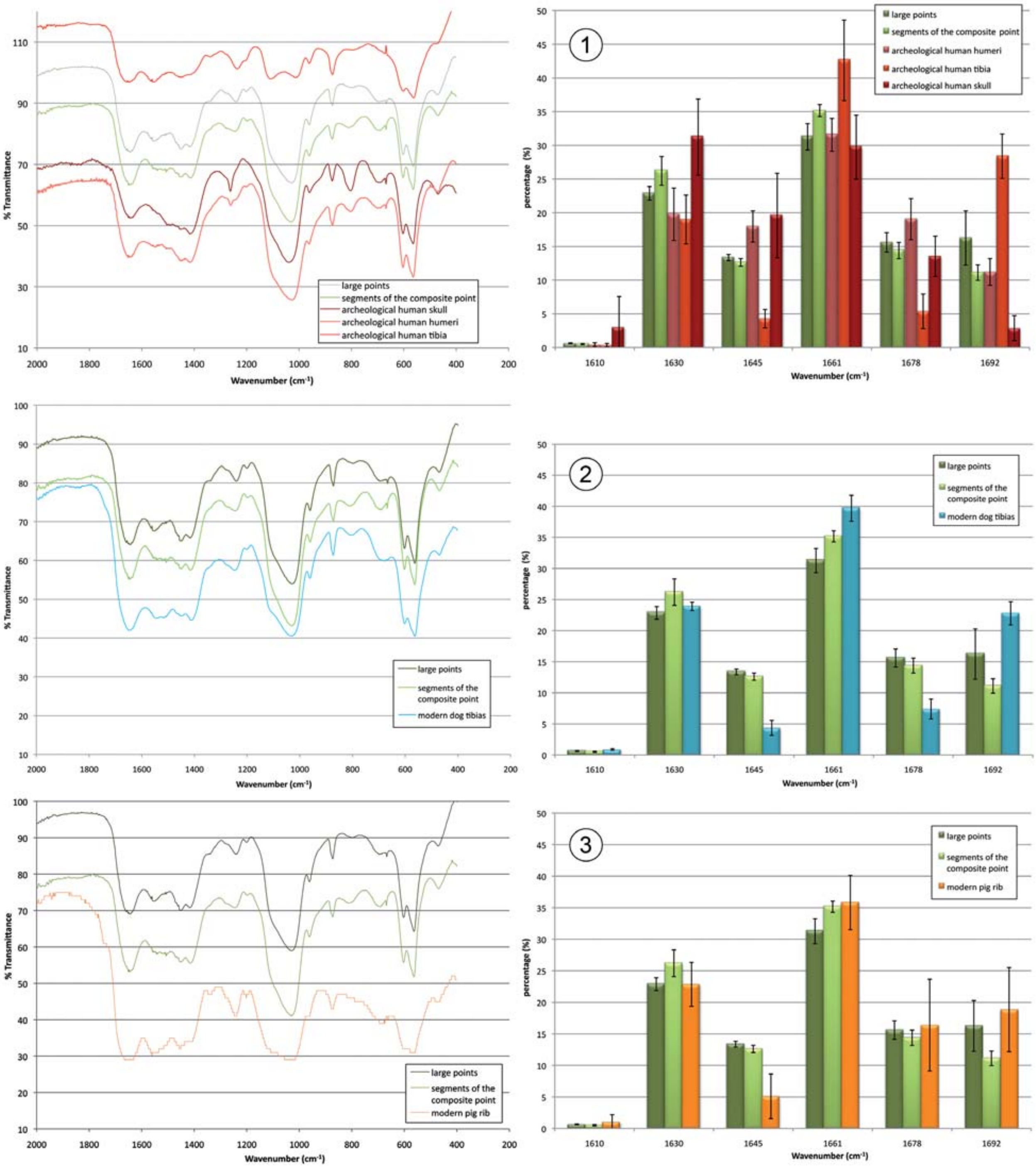

Fig. 9: FTIR spectra (left) and amide I histograms (right) of 4 Santa Cruz samples (13159-1, 13159-2, 13170-1, 13170-2) compared to the reference bones. 1: comparison with the human bones. 2: comparison with dog bone. 3: comparison with pig bone.

significant differences between the Santa Cruz and the human bone reference samples (Fig. 9: 1). Several differences can also be seen between the four Santa Cruz samples and the dog tibias (Fig. 9: 2: higher contribution of the 1661cm^{-1} and 1692cm^{-1} bands; lesser contribution of the 1645cm^{-1} and 1678cm^{-1} bands). Finally, pig bone is the sample that shows the closest resemblance to the four Santa Cruz samples (Fig. 9: 3), despite a difference in the contribution of the 1645cm^{-1} band.

In any case, according to these preliminary results, the hypothesis of human bone being the raw material used for arrowhead manufacture could neither be validated nor, taken the range of variability within a single species into account, definitely be disproved by the applied analytical method.

The micrographs from sample 13160-1 show that the material has a very heterogeneous structure, different from that of bone (e.g., no osteons: Fig. 10). FTIR spectra from this sample clearly differ from

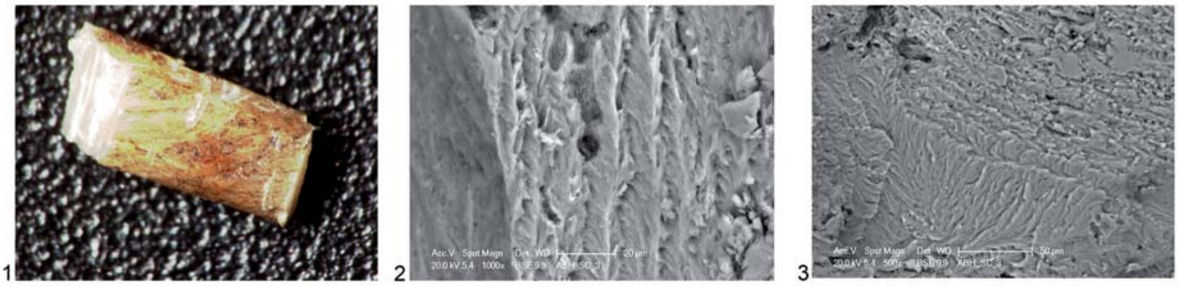

Fig. 10: Micrographs of sample 13160-1 (fragment of tine from base of small point). 1: Optical microscopy (x60). 2: SEM-EDS microscopy (x1000). 3: SEM-EDS microscopy (x500).

those of the reference bones, while the spectra from the four other samples are consistent with bone material (Fig. 11). It thus seems that sample 13160-1, unlike the others, is not made of bone. However, its spectral profile shares common absorption bands with keratin: it is therefore likely that this sample is made of a hard keratinous material (Paris 2004). Given the dimensions and the nature of the artifact, and the species locally available to the Santa Cruz islanders, the most likely candidate for this material is tortoise shell (exactly: scutes, the keratinous part of the shell; Frazier 2005).

Discussion

The identification of the raw material is based on samples taken from only a small number of artifacts. However, if we consider that these results are representative of the technical choices made by the makers of the arrows studied here, then it means that 88% of the arrowheads from our sample (i.e., all the 50 small points) are not likely to be made of bone, but instead, probably of keratinous material (tortoise shell?). The remaining 12% (i.e., the six large points and the composite point) are truly made of bone, but the type of bone used (human or other animal species) could not clearly be determined by the applied analytical method. Although the material analysis suggests the use of animal (pig?) bone for the manufacture of the arrowheads, certainly, given the experimental nature of the analytical method, the range of variability observed in a single species and the small number of reference samples (which, furthermore, did not include modern human bones), these results can only be considered as preliminary data[5]. The conclusion drawn of these preliminary results must therefore be reserved.

However, these preliminary results would not be consistent with the 19th century written sources mentioning the use of human bones to manufacture most of the war arrowheads on the Santa Cruz islands.

This possible discrepancy has no obvious explanation. The validity of the written sources might be questioned. However, it is unlikely that a similar information collected at different times (early and late 19th century) and different places (the two main Santa Cruz islands, Nendö and Vanikoro) is entirely due to errors and/or exaggerations made by the European writers.

The heterogeneous and patchy nature of our sources is a first possible explanation. The written sources mostly document Vanikoro in the early 19th century (Dillon 1830; Dumont d'Urville 1833) and Nendö in the late 19th century (Codrington 1891; O'Ferrall 1908), but the tradition of making arrowheads from human bones might simply not have been in practice at the time when – and/or at the place where – the arrows studied here were collected. It is also possible that these arrows were specifically made for trading with the Europeans, using materials of 'lower value'. Since the context of arrow collection is poorly documented, these possibilities cannot be ruled out.

A second possibility is the existence, in the culture of the Santa Cruz islanders, of a gap between the ideology and the actual technical practice. Arrow makers might have claimed that the heads of war arrows were made of human bone, while in reality, most of them were not made of bone – and even those that were really made of bone were not always manufactured from human remains. A similar discrepancy between the declared use and the actual use of hunting arrows was documented among the Danis in Papua (Pétrequin / Pétrequin 1990, 487). At present, this hypothesis cannot be demonstrated, but we must underline that it adequately accounts for several facts:

- The fact that human bone, as a source of raw material, is likely to have been available only in small amounts at a time and with a low predictability (linked to deaths in the local group and/ or to success at war), and thus might not always

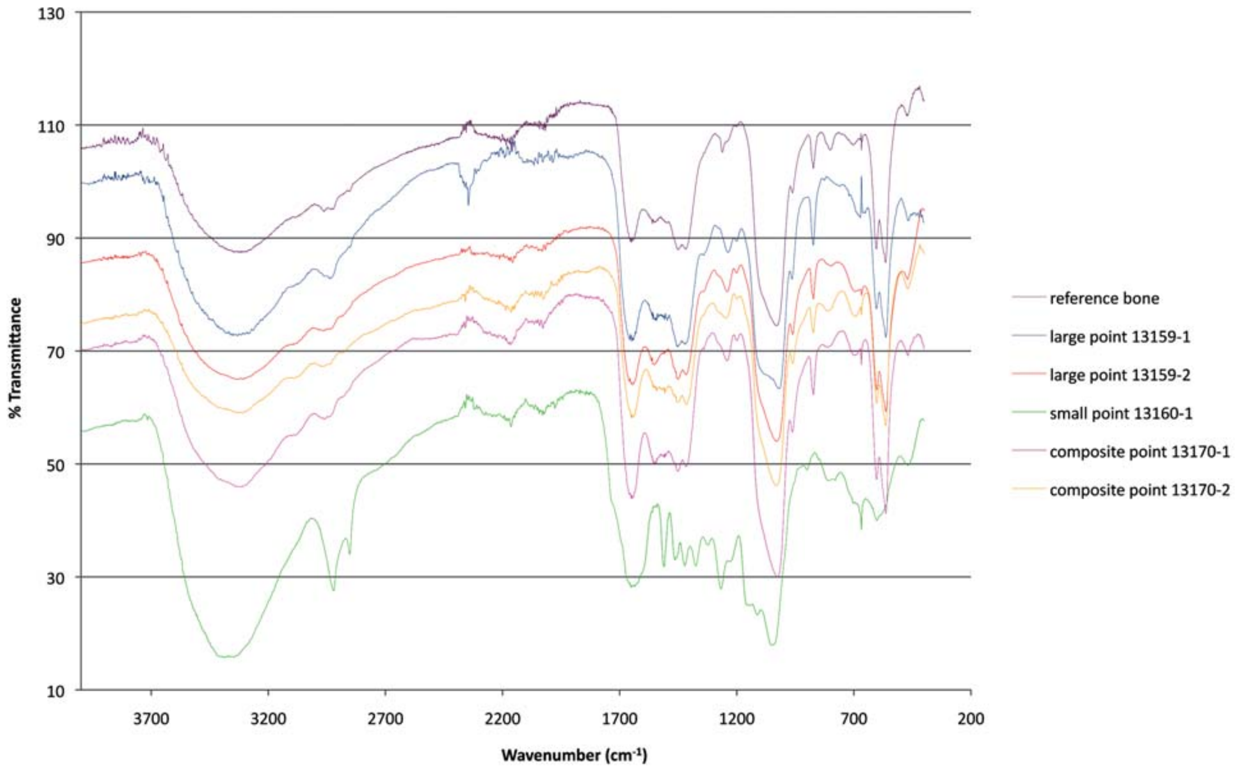

Fig. 11: FTIR spectra from the 5 Santa Cruz samples (13159-1, 13159-2, 13160-1, 13170-1, 13170-2) and from one of the Neolithic human bones (ABH_SF1). The spectrum from 13160-1 deviates from the 4 others, which are, conversely, consistent with the reference bone.

have been present in sufficient amounts to cover the need in the manufacture of war arrowheads;

- The fact that the manufacturing process of war arrows has not been directly observed by Europeans, and the information on the use of human bone is only reported from oral sources;
- The fact that one of the earliest direct observations of Santa Cruz war arrows, made on Nendö in 1793, mentions a more varied range of raw materials for point-making (bone, tortoise shell and stingray barbs: Labillardière 1800, 270-271);
- The fact that, according to the typological analysis, the hafting of the 'non-bone' arrowheads (i.e., the small points likely made of hard keratinous material) is designed to imitate the bone arrowheads: in this perspective, the design of the arrows would have been specifically intended to blur raw material distinctions to the non-expert eye.

Additional investigation – including new analyses on larger samples, and a closer investigation of ethnographic sources – is needed to further the discussion, and to ultimately place it in a wider anthropological issue: the conception of the human body as a source of raw material, and its articulation with actual technical practices.

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Notes

[1] "Tous deux étaient armés d'un arc et d'une vingtaine de flèches empoisonnées, dont la pointe était formée de fragmens d'os humains." (Authors' translation)

[2] "Mais ils sont convenus qu'ils exposaient les corps des ennemis, tués au combat, dans l'eau de mer, et les y laissaient assez long-temps pour que la chair se séparât entièrement des os. Ils gardaient les crânes comme trophées, et se servaient des menus ossemens des extrémités pour former la pointe de leurs flèches." (Authors' translation)

[3] "C'est du reste avec les os de leurs ennemis que les habitants de Vanikoro fabriquent les pointes de leurs flèches, et pour les obtenir ils commencent par faire macérer leurs cadavres dans la mer." (Authors' translation)

[4] "Die meisten Kampfpfeile (…) sind mit Knochenspitzen versehen (die angeblich aus den ausgegrabenen Arm- oder Beinknochen verstorbener Verwandter [Männer wie Frauen] geschnitzt sind)." (Authors' translation)

[5] A method already approved for species identification of archaeological bone is zooarchaeology by mass spectrometry (ZooMS: Buckley et al. 2009; 2010). ZooMS is a version of peptide (sometimes protein) mass fingerprinting, needing only small sample amounts (typically 1-5mg of a bone), which enables the determination of the animal genus – analogous to DNA fingerprinting but less accurate (van Doorn et al. 2011). FT-Raman or FTIR spectroscopy combined with chemometric data evaluation methods could also be applied for bone species discrimination (e.g., Mc Laughlin / Lednev 2012; Shimoyama et al. 1997).

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